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TECHNIQUES FOR THE STUDY OF LEARNING IN ANIMALS: ANALYSIS AND CLASSIFICATION[1]

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Although many different techniques for the study of learning in animals have been developed in the 60 years or so since the problem of animal intelligence first was brought into the laboratory, their interrelations never have been carefully defined. Crude dichotomies have been proposed—"respondent conditioning" versus "operant conditioning" by Skinner (1935, 1937), "classical conditioning" versus "instrumental conditioning" by Hilgard and Marquis (1940)—and, more recently, a trichotomy—"classical conditioning" versus "instrumental conditioning" versus "selective learning" by Spence (1956)—but the diversity of method is too great to be encompassed in any such one-way analysis. While certain differences among the techniques to be classified *must* be ignored if the number of categories is to be smaller than the number of techniques, the quest for parsimony seems to have been carried too far.

Classification is not merely a matter of taste. When one can find no objective basis for evaluating the conviction that a given difference in technique should be stressed or that another safely may be disregarded, it is only because the proper experiments have not been performed. Consider, for example, the question of whether the difference between flexion conditioning with avoidable as compared with unavoidable shock should be reflected in a classification of techniques. The answer is "Yes" for Hilgard and Marquis, who emphasize the contingency of reinforcement on response. They classify flexion conditioning as "classical" when shock is unavoidable and as "instrumental" when shock is avoidable. The answer is "No" for Spence, who emphasizes the degree of control afforded the experimenter over the appearance of the response to be learned. Ignoring the contingency of shock upon failure of response to the CS, Spence treats avoidance conditioning as a special case of classical conditioning in which the pattern of reinforcement gradually shifts from consistent to intermittent. Such a disagreement surely need not remain long in the realm of opinion. One has only to compare the behavior of an animal trained with avoidable shock and that of a control animal trained with shock that is unavoid-

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able but simply withheld on whichever trials the first animal avoids; if response contingency is unimportant, the course of learning in the two animals should be the same.

In general, a classification of techniques may be treated as the expression of a set of hypotheses about the functional significance of differences in technique—a distinction between two techniques as an assertion that they yield results which differ in some fundamental respect, and a failure to distinguish between two techniques as an assertion that they may be used interchangeably in the analysis of learning. This is not to say that a classification may not be preferred on historical, or on pedagogical, or even on esthetic grounds, but only that a functional interpretation is available which provides a basis for empirical evaluation. Methodological and functional considerations have, in fact, been linked rather closely in the past. Methodological distinctions have been taken as points of departure for dual-process analyses of learning, while strivings for a unitary conception have been reflected in the blurring of methodological distinctions. One may even point to experiments designed explicitly to provide a functional comparison of different methods (Youtz, 1938a, 1938b, 1939), although the empirical study of methodological interrelations certainly has not been carried very far.

Functional considerations play a central role in the classification to be offered here, which grows out of a program of comparative research (Bitterman, 1960). The first step in the program is to assess the phyletic generality of certain theoretically significant phenomena of learning which have been established in work with the rat (hitherto the principal subject of research on learning), and to that end a variety of simple animals must be studied under conditions analogous to those which have been used for the study of the rat; but what are "analogous" conditions? Clearly, the answer to this question requires some hypotheses about the essential properties of the various techniques which have been used for the rat. As will later be indicated, the comparative enterprise not only motivates further methodological analysis but constitutes a new source of data in terms of which the outcome may be evaluated.

Thorndikian Situations

It seems reasonable to begin the analysis with a set of closely interrelated techniques which date back to the turn of the century and which have yielded most of the information on which contemporary conceptions of animal learning are based. The adjective *Thorndikian* is appropriate both because of Thorndike's pioneering role in their development and because their operation is predicated on an empirical law of effect. Familiar examples are the problem box and the maze. In each of these situations, traditionally, the experimenter sets out to change behavior by manipulating its consequences, that is, by arranging a contingency between some motivationally significant state of affairs ("reinforcement") and the behavior in question. Thus, pulling a loop in a problem box or turning to the left in a T maze may be encouraged with food or discouraged with shock. Indeed, the motivational significance of any event may be assessed in terms of its effect on the response which produces it in such a situation. An event that facilitates the occurrence of a response upon which it is contingent is called a *reward;* an event that has the op-

posite effect is called a *punishment;* while an event that produces no measurable change in behavior is motivationally insignificant or neutral. An aversive stimulus is one whose onset is punishing, and in what is called *escape training* the offset of such a stimulus serves as a reward.

Unitary and Choice Situations

An important distinction between two main types of Thorndikian situation may be illustrated by a comparison of the problem box and the maze. In both these apparatuses, the animal is afforded numerous possibilities for action, one of which the experimenter chooses to reward. The main difference between them has to do with the treatment of irrelevant responses. In work with the problem box, the experimenter may take some qualitative notice of the variety of fruitless activities which appear, but his interest is centered on the rewarded response and the readiness with which it comes to expression. The basic datum is time. In the maze, by contrast, the unrewarded behavior of the animal is structured more clearly; certain major alternatives to correct response are delineated, and the interest of the experimenter is centered on their decline and disappearance. The basic datum is error. Time may be recorded, but it does not as clearly reflect progress in the choice among alternative courses of action, the aspect of selective learning which the maze is so well suited to display.

The designation *unitary* Thorndikian situation (or T-1 situation) will be used here for the problem box and for any other Thorndikian situation in which but a single course of action is defined and the readiness with which it comes to expression is measured. The designation Thorndikian *choice* situation (or T-2 situation) will be used for the maze and for any other Thorndikian situation in which two or more incompatible courses of action are defined and choice among them is studied. The nature of the responses delineated and the general properties of the environments in which they appear are ignored in this classification. Thus, a problem box which offers a choice of manipulanda is classed with the maze as a T-2 situation, while the runway is classed as a T-1 situation despite its structural resemblance to the maze. The runway may, of course, provide a measure of error, as in the early works of Hicks (1911), who plotted the learning of a culless maze in terms of retracing, while the potentialities of the maze for the study of choice may be ignored, as in the early work of Thorndike (1898), who, measuring only time, used the maze as though it were just another problem box. In such cases, the classification is based on the use to which the apparatus actually is put in a given experiment. For the most part, however, contradictions between potentiality and use are rare. An investigator interested in choice among alternative courses of action is not likely to use a runway, nor, unless he is interested specifically in choice among alternative courses of action, is he likely (today) to use a maze.

Both T-1 and T-2 situations may be "chained." The most common example of a chained T-2 situation is the maze of many choice-points, once very much the mode, but rarely encountered today, perhaps because of the conviction, expressed by Lashley (1918), that the single-unit maze is quite as sensitive as the multiple-unit maze to the effects of significant variables and much less costly in time and effort. (The two

kinds of apparatus are not, of course, fully equivalent; certain problems—such as that of correction versus non-correction, first studied by Lashley—arise only when the number of choice points is reduced to one, while other problems—such as that of serial order—disappear.) Chained T-1 situations never have been widely used. An example may be found in a string of problem boxes, each presenting one manipulandum, with the first giving access to the second, the second to the third, and so on, until the reward finally is attained (Herbert & Arnold, 1947). For certain purposes, conceivably, mixed chains (composed both of T-1 and of T-2 units) might be used.

Generalized and Discriminative Situations

Each of the two types of Thorndikian situation already distinguished —*unitary* and *choice*—may occur in *discriminative* as well as in *generalized* form. This new distinction, which is orthogonal to the first, will be conveyed by adding the letters g (for generalized) and d (for discriminative) to the symbols for unitary and choice: T-1g, T-1d, T-2g, T-2d. In a discriminative problem, the experimental environment is varied systematically from trial to trial, and with it the consequences of response, the capacity of the animal to discriminate the change being inferred from a corresponding variation in behavior. In a generalized problem, there may be some variation in the experimental environment from trial to trial (intentional or unintentional), and there may be some variation in the consequences of response (as in work on partial reinforcement), but there is (by definition) no correlation between the two kinds of change, and hence there is no objective basis for systematic variation in behavior.

In the simplest T-1d case, a single defined response is rewarded under one set of conditions but not rewarded (or punished) under another set of conditions, and the readiness with which the response comes to expression under the two conditions is compared. For example, response in a single-window jumping apparatus is rewarded when a white card is displayed but punished when the card displayed is black (Solomon, 1943). Performance in a T-1d problem may be expressed in terms of "error," but a temporal criterion is implied. For example, in an early experiment by Thorndike (1898), cats were fed for climbing to the top of their cage in response to the words "I must feed those cats," but not for making the same response to the words "Tomorrow is Tuesday," an error being recorded whenever they climbed up (promptly) to the second phrase or failed (in a reasonable period of time) to climb up in response to the first. Similarly, Grice (1949), working with another T-1d situation, computed the median response time for a series of trials and counted as an error any response to the negative stimulus faster than the median or any response to the positive stimulus slower than the median. A clear distinction should be made between error thus defined and erroneous choice in a T-2d situation.

In a T-2d problem, two or more alternative responses are defined—two in the simplest case. One of the responses is rewarded and the second unrewarded (or punished) under a given set of conditions, while the consequences of the two courses of action are reversed under another set of conditions, and erroneous choices are counted. For example, in a conventional jumping apparatus, a jump to the right window is rewarded when the card in the right window is

white and the card in the left window is black, but a jump to the left window is rewarded when the positions of the two cards are interchanged; or, in the same apparatus, response to the right window is rewarded when two white cards are displayed, but response to the left window is rewarded when two black cards are displayed. (Problems of the first kind have been termed "simultaneous" while problems of the second kind have been termed "successive," an adjective applied as well to T-1d problems; considerable confusion has resulted from the failure to distinguish between T-1d and successive T-2d problems.) The so-called "higher order" discriminations—oddity, matching-from-sample, and multiple choice—also may be classified as T-2d problems, although they seem to make demands which go far beyond those of the simpler problems first exemplified. The T-1d and T-2d categories actually are rather coarse ones which themselves invite careful analysis and subdivision.

Like T-2g situations, T-2d situations may be "chained"—as when an animal is required to make a series of choices based on brightness before the reward is attained (Stone, 1928). Meaningful T-1d chains also are possible, although no instance of such a chain is to be found in the literature. For example, response to a manipulandum in one unit gives immediate access to the next unit when the positive stimulus is present; when the negative stimulus is present, access to the next unit is given after a predetermined period of time whether or not the animal responds.

Discrete and Continuous Situations

There has been little clarity on the relation of Skinner's technique to other techniques for the study of learning in animals. It has been asserted by Woodworth (1938), for example, that the Skinner box "bridges the gap" between the problem box and the classical conditioning situation, and a similar view is met again in Spence (1956), who places the Skinner box on a continuum at a point intermediate between the methods of Thorndike and Pavlov; but the notion of continuity is difficult to justify. Skinner (1935, 1937) certainly has succeeded very well in drawing a sharp line between his method and that of Pavlov on the basis of criteria which fail to distinguish his method from that of Thorndike.

Skinnerian situations are Thorndikian situations as the term is defined here. The original Skinner box differs from the older problem box only in that it delivers food to the response compartment (instead of admitting the animal to a separate feeding compartment) when the defined response is made, a feature which eliminates handling of the animal between trials. Equipped with a retractable lever, which is introduced to begin each trial and withdrawn after response, the Skinner box may be used in exactly the same manner as the older problem box; in fact, a retractable manipulandum which delivered food to the responding animal was developed for the monkey by Thorndike himself (1901). Skinner (1932), of course, has preferred to use his apparatus as a "repeating" problem box—his own adjective—inverting the traditional measure of performance, and substituting for time per response on discrete trials number of responses per unit time (rate of response) to a continuously available lever. Either way, a Skinner box containing one lever may be classified as a T-1 situation. A single response is delineated, its consequences are

manipulated, and the readiness with which it comes to expression is measured. With two levers and the study of choice, the Skinner box becomes a T-2 situation.

It seems reasonable, nevertheless, to make a formal distinction between Thorndikian situations in which latencies or choices are measured in discrete trials and their Skinnerian counterparts in which rates of response are measured under conditions of continuous opportunity to respond. Situations of the first kind will be designated as *discrete*, while those of the second kind will be designated as *continuous*, and for symbolic purposes the subscripts d (for discrete) or c (for continuous) will be added to the T for Thorndikian, as, for example, in T_d-2g (discrete, choice, generalized) or in T_c-1d (continuous, unitary, discriminative). The discrete-continuous distinction reflects the hypothesis that rate of response, despite its close mathematical relation to latency, has a functional significance which is to a certain extent unique, and some interesting evidence for this view comes from comparative studies of the effect of inconsistent reinforcement on resistance to extinction. In the rat, discrete and continuous techniques both give the so-called paradoxical effect (greater resistance to extinction after inconsistent than after consistent reinforcement). In the fish, initial resistance to extinction is greater after consistent reinforcement in the discrete case (Longo & Bitterman, 1960; Wodinsky & Bitterman, 1959, 1960); but some as yet unpublished data show greater resistance to extinction after inconsistent reinforcement in the continuous case. Whether the difference in outcome may be traced to a difference in the functional properties of the two techniques, or whether it is a product of certain parametric differences between the two sets of experiments, remains to be determined. The matter is introduced here only to suggest the possibility that techniques which are functionally equivalent for one species may not be so for others. In this connection it is worth noting, perhaps, that the potentialities of the rate measure seem to be realized fully only when inconsistency of reinforcement is introduced.

A General Definition of Thorndikian Situations

In each of the Thorndikian situations considered thus far, a change in behavior is measured which springs from a contingency between some defined response and some motivationally significant state of affairs. Experiments on latent learning suggest, however, that a Thorndikian situation may be characterized without reference either to the actual occurrence of change in behavior or to the motivational significance of the consequences of response. In the T-1 case, an investigator may set out deliberately to minimize the motivational significance of the consequences of response in an effort to minimize the extent of change in behavior. For example, a hungry rat is trained in a runway which leads to an empty end box or to one which contains only water. To arrange a set of end-box conditions which are entirely without motivational significance is not, of course, always very easy, but it can be done (Gonzalez & Diamond, 1960). In the T-2 case, the consequences of alternative responses, whether motivationally significant or not, may be balanced in an effort to forestall the development of a preference for one or the other response. For example, a hungry rat is run in a simple T maze with both end boxes empty, or one empty and the other containing only water, or one containing food

and the other both food and water; or a rat that is both hungry and thirsty is run in a T maze with one end box containing food and the other containing water. Such situations are intended merely to provide occasions for learning whose effects are estimated in later tests. The tests always involve a change in the motivational significance of the consequences of response: for example, food is added to a previously empty end box; or the end box is associated with food in direct feedings; or the prevailing condition of deprivation is altered, and with it the relevance of previously encountered incentives. Nevertheless, despite the careful attention which must be paid to motivational significance in evaluating the outcome of exposure to a Thorndikian situation, the situation itself may be defined without reference to motivational significance. What is essential only is *a contingency of some specified event or circumstance on some measurable bit of behavior*—a contingency arranged by an investigator who is interested in studying its effects on the animal.[2]

[2] No treatment of Thorndikian techniques would be complete without some mention of a set of situations closely related to the problem box (calling for string-pulling, rake-wielding, box-stacking, and the like) which figured prominently in the work of certain of Thorndike's critics, beginning with Hobhouse (1901), who did not think that Thorndike's apparatus provided a representative picture of animal intelligence. Designed to be fully "surveyable" (to conceal nothing from the animal) and, although simple in principle, to render "chance" solutions unlikely, these (Hobhousian) situations present Thorndikian contingencies of a rather loose sort and *may* be used, like Thorndike's problem boxes, to study the way in which the experience of such contingencies affect subsequent behavior. Their principal use, however, has been in inquiries into the ability of animals to discover appropriate modes of behavior in advance of reinforcement—that is, in quests for evidence of "productive" or "inferential" as contrasted with "reproductive" or learned solutions.

Pavlovian Situations

Well before Pavlov's experiments on conditioning became widely known, other investigators were led quite independently, by an interest in associative learning, to experiments of essentially the same kind. As far back as the turn of the century, a distinction was made between what was called "trial-and-error" or "selective learning"—the modification of behavior as a function of its consequences—and what was called "association of stimuli" or "substitution" —the acquisition by one stimulus of some of the behavioral properties of a second stimulus as a function of the pairing of the two stimuli. Primarily concerned though he was with selective learning, Thorndike (1898) himself made use of paired stimulation; when a verbal statement such as "I must feed those cats" was followed regularly by the presentation of food, he reported, the words alone would bring the animals to the feeding place. It seems fitting nonetheless—in view of the scope of Pavlov's (1927) contribution—that the method should bear his name.

In the traditional Pavlovian experiment, as in the traditional Thorndikian experiment, the behavior of the animal is altered by the introduction of some motivationally significant stimulus such as food or shock ("reinforcement"), but there are important differences. In a Thorndikian experiment, reinforcement is contingent on response; doing one thing leads to food or to shock, doing another does not. In a Pavlovian experiment, reinforcement is scheduled without regard to response; the experimenter does not set out to mold behavior in some predetermined fashion, but only to study the way in which the functional properties of one stimulus are altered by virtue of its contiguity with another. Because their introduction is not

contingent on the animal's behavior. Pavlovian reinforcements cannot be treated as rewards or punishments in any meaningful manner, nor can rewards and punishments be distinguished in a Pavlovian experiment. Another difference between the two techniques is worth noting. In a Thorndikian experiment, the choice of the behavior which is to serve as the index of learning is independent of the choice of reinforcement; any of a large variety of responses which the animal is likely to make may be encouraged with food or discouraged with shock. In a Pavlovian experiment, the choice of reinforcement restricts the choice of a behavioral indicator; while the conditioned and unconditioned responses are not always (as Pavlov thought) identical, the investigator must be guided in his search for evidence of learning by the functional properties of the reinforcing stimulus. Sharp as the distinction may be between the traditional Thorndikian and Pavlovian procedures, it has been ignored very often by theorists preoccupied with the task of deriving all of the data of learning from the operation of a single process. Pavlov himself claimed, of course, that all instances of learning could be analyzed as instances of conditioning, although Thorndike, committed as he was to the generality of the law of effect, never was satisfied that Pavlov's procedure could be cast in the same mold as his own.

Coordinate with the unitary Thorndikian (or T-1) situation is the unitary Pavlovian (or P-1) situation, in which the tendency for a CS to produce some defined effect is measured in terms of latency or magnitude. The defined effect may be a response which is reflexly elicited by the US, as in the salivary conditioning experiment, or something quite different, as when the rate of fixed-interval responding in a Skinnerian situation is depressed by shock and by a stimulus paired with shock (Estes & Skinner, 1941). A P-1 situation may be generalized (P-1g) or discriminative (P-1d); in the discriminative case, the CS is varied systematically from trial to trial and with it the likelihood that the US will be presented (as, for example, when a bright light always is followed by food but a dim light never is). With two unconditioned stimuli, each eliciting a different response, it is possible to set up a P-2 situation, the Pavlovian analogue of the Thorndikian choice situation. (A T-2 situation may be constituted with but a single reinforcer, which is another interesting difference between Pavlovian and Thorndikian techniques.) The discriminative (P-2d) case is perhaps the easier to conceive than the generalized (P-2g). For example, one CS is paired with acid introduced into the mouth of a dog, while another CS is paired with meat-powder (Pavlov, 1927). The P-2g case must involve some inconsistency of reinforcement (which is, or course, not true of T-2g). For example, a CS is paired with shock to the right forelimb on a random 75% of trials and with shock to the left forelimb on the remaining 25% of trials. This is the Pavlovian analogue of a kind of T-2 situation in which there has been much interest of late. For example, a right turn at the choice point of a maze leads to food on a random 75% of trials while a left turn leads to food on the remaining 25% of trials (Brunswik, 1939).

The discrete-continuous dichotomy, which was developed in the analysis of Thorndikian procedures, seems to have no Pavlovian parallel; Pavlovian training is an affair of discrete trials. Nor does the notion

of "chaining" have any application to Pavlovian procedures.

A Pavlovian situation, like a Thorndikian situation, may serve merely as an occasion for learning whose effects are measured in subsequent tests. One such case, well known to Pavlov, is that in which the presentation of CS and US is strictly simultaneous; only when the training procedure is altered can the effects of pairing be assessed. A second is that of "sensory preconditioning"—conceived originally by Thorndike (1898) himself as a check on the existence of "representations"—which is analogous to the Thorndikian experiment with consequences of response which are lacking in motivational significance; neutral stimuli are paired, then one is given some behavioral property, and the effects of the pairing are estimated from response to the other. A third case is that in which attention is centered on the acquisition, not of response-eliciting properties, but of rewarding properties (Williams, 1929); for example, an animal is fed repeatedly in a distinctive box (that is, box and food are paired), after which access to the empty box is made contingent upon response in a Thorndikian situation. In one variety of experiment which has considerable theoretical importance, the order of these experiences is reversed; the contingency of access to the empty box upon some response is displayed, after which the animal is fed in the box, and the effect on response is measured (Gonzalez & Diamond, 1960). In general, then, a Pavlovian situation may be defined without reference either to the occurrence in that situation of any particular kind of behavioral change, or to the functional properties of the stimuli which are paired. What is essential only is *a sequence or conjunction of stimuli whose contiguity is independent of the animal's response.*

Avoidance Situations

The only learning situations which cannot be classified unequivocally as Pavlovian or Thorndikian are those which involve the avoidance of aversive stimulation. In them, Pavlovian and Thorndikian features are closely intertwined. On the one hand, a neutral stimulus is paired with an aversive stimulus, thereby acquiring certain arousing properties. The pairing is not, on the other hand, entirely independent of the animal's behavior—the aversive stimulus is introduced only *if* the CS fails to elicit some defined response, whose likelihood of occurrence (low at the outset) the pairing serves to increase. This contingency of reinforcement on response is not displayed on the very first trial, as it is in a pure Thorndikian situation. In avoidance training, the contingency is a negative one, which (since the mere possibility of avoidance cannot influence the animal) does not become manifest until the Pavlovian procedure has taken effect.

There is another Thorndikian contingency which operates in some (though not in all) avoidance situations, this one making itself felt from the very first trial: termination of the aversive stimulus may be contingent on some defined response, often—but not always—the same response as that which avoids the aversive stimulus. In flexion conditioning, when shock to the limb is administered through a grid on which the limb of the animal rests, and when the scheduled duration of shock is substantial, flexion both escapes and avoids shock. In the shuttle box, too, the conditions of training may be such that changing compartments both escapes and avoids shock, al-

though, as Warner (1932) noted early, the response which escapes shock may be different from that which avoids it (for example, leaping over a hurdle as compared with crawling under). It is possible, of course, to set up an avoidance situation in which there is no escape at all. In flexion conditioning, shock may be administered through a bracelet attached to the limb, and a control circuit so arranged that the CR will forestall the shock but the UR will not alter its scheduled duration. In the shuttle box, the shock may be very brief, terminating quite independently of any response the animal may make to it (Hunter, 1935). Even without escape, however, there remains the contingency of aversive stimulation on failure of response to the CS, an essential feature of avoidance training which distinguishes it from Pavlovian training, while the paired stimulation which is responsible for the emergence of response to the CS distinguishes it from Thorndikian training. Avoidance training seems to require a major category of its own.

In its most common use, the shuttle box may be classified as an A_d-1g situation (A for avoidance); a single course of action is defined, and its latency is measured in discrete trials without systematic variation in sensory conditions. The corresponding discriminative (A_d-1d) situation also may be generated in the shuttle box; for example, a bright light is followed by shock unless the defined response is made, but a dim light never is followed by shock. In such a situation, it may be noted, discrimination can progress only as the animal fails to respond to the dim light, since the consequences of response to the two lights are identical. (In a T-1d situation, by contrast, the consequences of response to the stimuli to be discriminated are different, and discrimination therefore is facilitated by response to the negative stimulus; in a P-1d situation, discrimination may progress quite independently of response.)

Choice among alternative courses of action also may be studied in avoidance situations. Suppose, for example, that shock from a grid in the floor of a T maze is scheduled x seconds after an animal is placed in the starting box. In the generalized (A_d-2g) case, shock is avoided by prompt entrance into the end box on the right, but not by entrance into the end box on the left. In the discriminative (A_d-2d) case, a turn to the right avoids shock when the stem of the maze is black, while a turn to the left avoids shock when the stem is white. Two unconditioned stimuli are not required to generate an A-2 situation as they are to generate a P-2 situation, but two unconditioned stimuli may be used. For example, one signal is followed by avoidable shock to the right limb, while a second is followed by avoidable shock to the left limb (James, 1947).

The discrete-continuous dichotomy developed in the analysis of Thorndikian situations is applicable also to avoidance training. An A_c-1g situation may be constituted in a modified Skinner box or a shuttle box. In a design developed by Sidman (1953), no exteroceptive warning signal is used, but shock is scheduled every x seconds by a clock which the defined response resets. (The lack of an exteroceptive signal does not, of course, subvert the definition of avoidance training as originating in a quasi-Pavlovian contiguity of stimuli; as Pavlov himself showed, internal processes correlated with the passage of time since the occurrence of a specified event may be cast in the role of CS). In the corresponding

discriminative (A_0-1d) case, the clock which schedules shock runs only under one of two sensory conditions. Avoidance situations of the continuous type which do involve exteroceptive signaling also are feasible. In the A_0-1g case, for example, shock from a grid in the floor of a Skinner box is scheduled x seconds after the onset of a light and avoided by response on a variable-ratio schedule. A_0-2 situations, both generalized and discriminative, may be generated when alternative courses of action are defined.

Like Thorndikian situations, avoidance situations may be chained. Just as an animal may learn to run a simple T maze under threat of shock, so it may learn to run a multiple T maze. An example of chaining in an avoidance situation of the continuous type is the following: with the onset of the CS, response to one manipulandum is followed, on a variable-ratio schedule, by access to a second manipulandum, response to which, again on a variable-ratio schedule, terminates the CS and avoids shock.

Although the term implies threat of an aversive condition which the animal learns to forestall, avoidance training, like Thorndikian and Pavlovian training, may be characterized without reference to the nature of the stimuli employed or to the occurrence of behavioral change. It would be possible, for example, to train an animal with some neutral stimulus rather than shock in a shuttle box designed to produce a substantial frequency of spontaneous crossing, and then to test for learning after the neutral stimulus has been paired with shock. Irrespective of outcome, the conception of such an experiment is sufficient to delineate what is here regarded as the essential feature of avoidance training: *a sequence of stimuli is scheduled with the occurrence of the second contingent upon the failure of the animal to make some specified response to the first.*

Terminology

While there need be no detailed comparison of the classification here proposed with earlier ones, it may be worth while, in the interest of preserving whatever compatible usages may exist, to consider how well some of the broader methodological designations which now are current will serve the needs of the new classification. Since current terminology derives from earlier classifications, the major differences in emphasis must become quite apparent in the process.

The term "conditioning" usually is used for the kind of training here called Pavlovian, but that term also is used rather widely to designate techniques which are not here classified as Pavlovian, and often as a synonym for "learning" itself. The term "classical conditioning" is closer to what is here intended by Pavlovian, although in some contexts it has a narrower meaning (suggesting a harnessed animal) and in other contexts a broader one (encompassing avoidance). Avoidance remains a useful term, but "instrumental conditioning" is too ambiguous, since it has been applied indiscriminately both to avoidance training and to pure Thorndikian training. The term "operant conditioning" is even more ambiguous; it has a narrow (Skinnerian) sense in which it is tied to a questionable distinction between "elicited" and "emitted" behavior, as well as a more general sense in which it is equivalent to instrumental conditioning. The term "selective learning" has a pure Thorndikian connotation, but it seems to designate a process of learning rather than a method of studying it.

In general, there is little to salvage in the current terminology. Specific situational designations, such as maze, problem box, and runway, continue to be useful, but the broader classificatory terms are unsuitable because they are geared to methodological dichotomy rather than to trichotomy. Even if dichotomy should in time give way to trichotomy, of course, it is likely that many of the older terms will continue to be used with altered meanings and with considerable consequent confusion. The terms for the subcategories here defined—unitary and choice situations, generalized and discriminative situations, discrete and continuous situations—fortunately do not compete with established usages and therefore create less opportunity for confusion, although it is possible that a clearer notation might be found. Reflection will show, however, that complexity of notation is to a certain extent an inevitable consequence of the amount of information to be conveyed.

It is natural that a new classification should require a new terminology, although a change in classification does not, of course, necessarily imply an advance in conception. Whether the classification here proposed represents an advance in thinking about the interrelations among learning situations cannot now be told. Classification is more, ultimately, than a matter of taste, but there is little else on which to depend at the present time. It is to be hoped that a renewed concern with problems of classification will stimulate further research on methodological interrelations.

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